TECHNICAL MANUAL

INSTRUCTIONS

AND

PARTS BREAKDOWN

for

HICKOK

PREAMPLIFIER

MODEL 1824

THE HICKOK ELECTRICAL INSTRUMENT CO.

Cleveland 8, Ohio

TABLE OF CONTENTS

SECTION		PAGE
I.	USE AND MAINTENANCE	1
	1. Purpose	1
	2. Quick Reference Data	1
	3. Description of Front Panel Controls and Connectors	1
	4. Operating Instructions	2
	5. Circuit Description	3
	6. Maintenance Instructions	3
	7. Operational Adjustments	3
	8. Trouble Shooting	5
II.	PARTS BREAKDOWN	7
	1. General	7
	2. Use of Replacements Part List	7

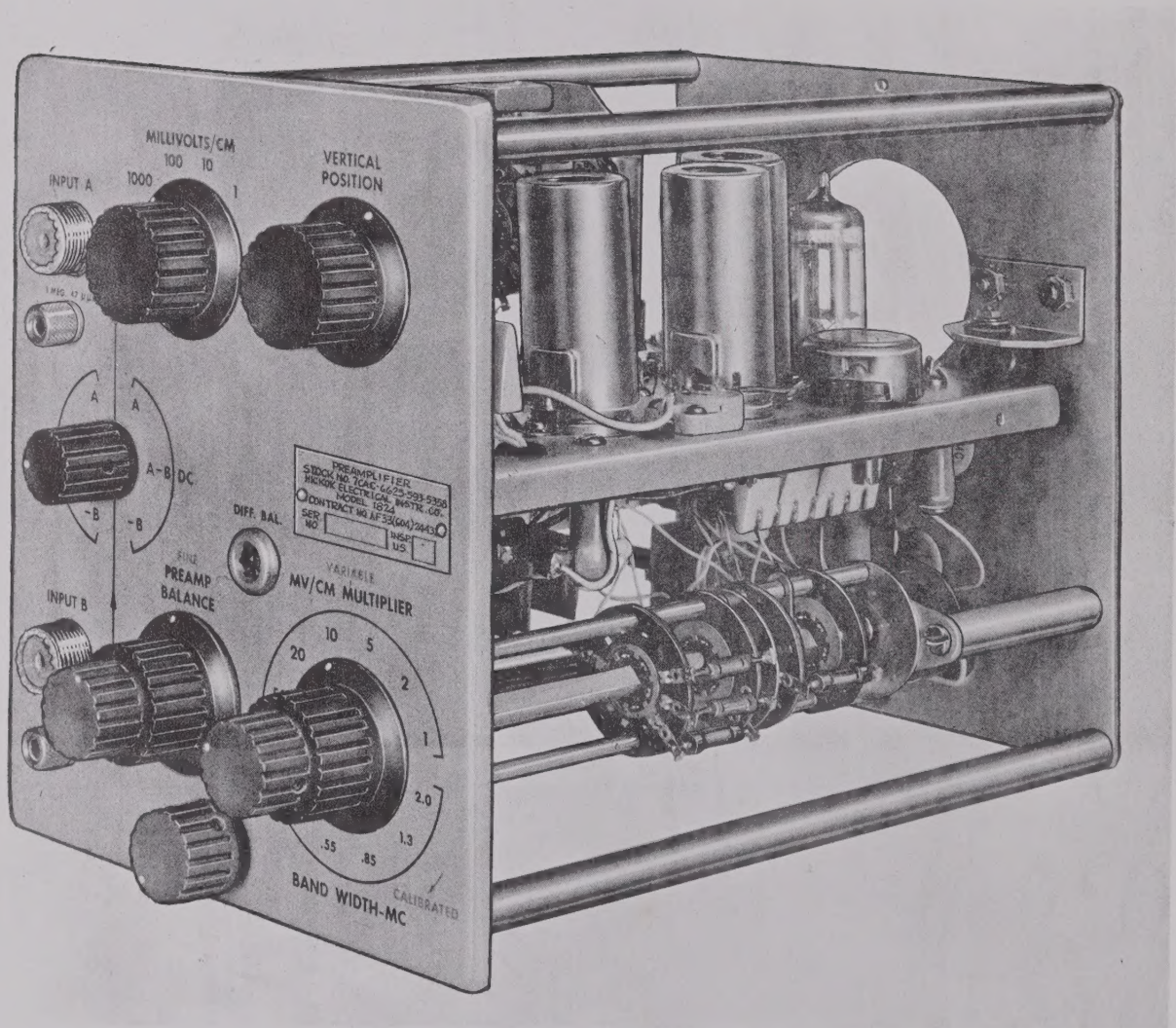

Figure 1-1. Identifying View of Model 1824 Preamplifier

SECTION I

USE AND MAINTENANCE

1. PURPOSE.

a. GENERAL. The Model 1824 plug-in-unit is a high-gain differential preamplifier. Calibrated sensitivity from 1 mv/cm to 50 v/cm, continuously variable, permits cancellation of unwanted or interfering signals. The Model 1824 plug-in-unit is manufactured by Hickok Electrical Instrument Co., Cleveland, Ohio.

b. When the input selector is in the AC position a capacitor is inserted in series with the input to remove the DC component of the signal. In the two positions of the switch marked A-B, both inputs are connected to the amplifier, and the signal presented to the main amplifier in the oscilloscope is the difference between the two signals connected to INPUT A and INPUT B.

2. QUICK REFERENCE DATA.

a. Power is applied to the Plug-In-Unit Preamplifier by the oscilloscope through an interconnecting receptacle in the Preamplifier compartment. The power switch on the oscilloscope controls power application to the oscilloscope and preamplifier simultaneously.

CAUTION

Do not attempt to operate oscilloscope without preamplifier. Voltage regulation will be seriously altered.

b. ELECTRICAL CHARACTERISTICS. The 1824 Preamplifier has calibrated sensitivity from 1 MV/CM to 50 V/CM continuously variable to 125 V/CM, with a frequency response from DC to 350kc at 1 MV/CM sensitivity, increasing to DC to 2 MC at 50 MV/CM and lower sensitivities.

c. The 1824 preamplifier differential input rejection ratio for common mode signal is greater than 10,000 to 1, DC-coupled. At low frequencies, in the AC-coupled position, the rejection ratio decreases with frequency; the rejection ratio at 60 cps, AC-coupled, is about 600 to 1.

3. DESCRIPTION OF FRONT PANEL CONTROLS AND CONNECTORS AS SHOWN IN FIGURE 1-1.

(1) INPUT A AND INPUT B. Separate signal inputs to the preamplifier by way of the input selector switch.

(2) MILLIVOLTS/CM. Four position switch to insert attenuators between the signal inputs and the amplifier.

(3) VERTICAL POSITION. Potentiometer to move the trace vertically.

(4) DIFF BAL. Screwdriver adjust potentiometer sets DC differential bias on input tubes to provide a fine differential adjustment of the input stage gain, so that maximum in phase rejection will be obtained with differential input.

(5) VARIABLE. Potentiometer, concentric with the deflection sensitivity switch to provide continuously variable attenuation between the calibrated sensitivities and to decrease the sensitivity to 125 v/cm.

(6) MV/CM MULTIPLIFER. Six-position switch to change gain of amplifier and provide 15 calibrated sensitivities in conjunction with the MILLIVOLTS/CM

Type	High gain, differential input
Number of Tubes	6
Frequency Response	
High	2 MC, 50 MV/CM
Low	350 KC, 1 MV/CM
Input	AC-DC coupled
Maximum Allowable DC Component at 1 mv/cm; (A-B)	DC 5 Volts
Input Impedance	either grid 1 megohms 47 uuf
Weight	4 pounds

Table 1-1. Table of Specifications

TUBE DESIGNATION NUMBER	TUBE TYPE	FUNCTION
V1101	12AU7	Cascode Stage
V1102	12AU7	Cascode Stage
V1104	5879	Gain Control Stage
V1105	5879	Gain Control Stage
V1106	12AU7	Output Cathode Follower
V1103	12AU7	Voltage Setting Cathode Follower

Table 1-2. Table of Electron Tube Complement

switch.

(7) PREAMP BALANCE. Seven-position switch to balance the DC voltages on the plates of the input cascode amplifiers.

(8) FINE. Potentiometer to provide a fine adjustment of the DC balance on the input-amplifier plates.

(9) INPUT SELECTOR SWITCH. Six-position switch providing choice of either input separately, or the two inputs differentially, with either AC or DC coupling.

4. OPERATING INSTRUCTIONS.

a. GENERAL. The Model 1824 High Gain Differential Preamplifier is designed to operate as a preamplifier for general purpose Model 1805 oscilloscopes. Be sure to let the preamplifier warm up for a few minutes after you first apply power to it so that it can stabilize. Normally it will be quite stable after about 5 minutes.

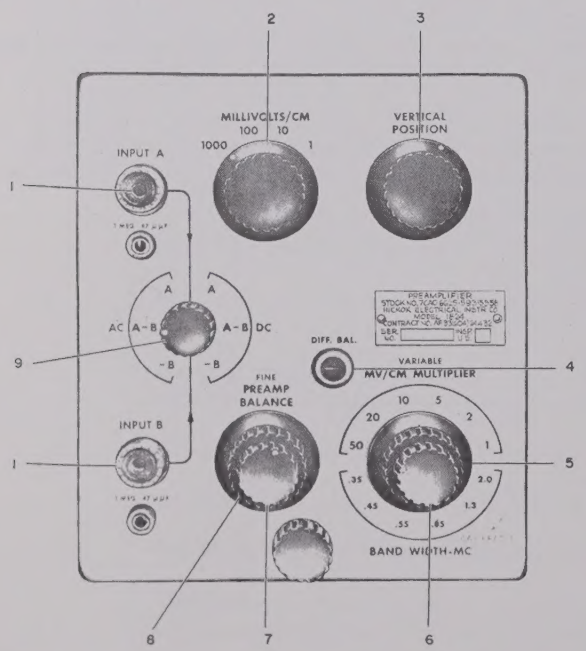

Figure 1-2. Front Panel Controls and Connectors

b. SIGNAL INPUT CONNECTIONS. Either of the two signal inputs can be used independently by turning the INPUT SELECTOR switch to one of the two inputs and connecting the signal to the corresponding input connector. In order to remove the DC component of the signal, turn switch to AC position to insert a capacitor in series with the input.

c. DEFLECTION SENSITIVITY. Except when sensitivity in excess of 10 millivolts per centimeter is required, keep the MV/CM MULTIPLIER control in the 10, 20, and 50 positions. In these positions the reduced amplifier gain provides improved stability and increased frequency response. This is especially helpful in reducing the warm-up drift.

NOTE: The VARIABLE attenuator must be turned full right to calibrated position for the indicated deflection sensitivity to agree with the ruled lines on graticule. The ten-times-attenuation probe furnished with the oscilloscope will extend the attenuation to a maximum of 1250V/CM and reduce the loading on the circuit under test to 10 megohms shunted by about 12 uuf. The peak voltage to ground applied to the probe should not exceed 600 volts. Large signals must be externally attenuated. Occasionally, when measuring small AC signals in the presence of large DC voltages, it may be necessary to adjust the VERTICAL POSITION control to return the trace to the screen.

d. PREAMP BALANCE. The input cascode amplifier can be balanced by means of the concentric front panel PREAMP BALANCE controls. The trace will not shift vertically when the MULTIPLIER switch is rotated, if these controls are set properly. To make the adjustment, set the MILLIVOLT/CM switch to 100 and the MULTIPLIER switch to 50. Position the trace near center and turn the MULTIPLER switch to 20. Return the trace to center with fine control and if necessary PREAMP BALANCE switch. Continue turning MULTIPLIER to 10 and 5 positions, adjusting PREAMP BALANCE as necessary, until no trace shift remains when MULTIPLIER switch is switched between 5 and 50 positions. Any shift remaining when MULTIPLIER CONTROL is switched to 1, may be compensated for by readjustment of fine control until 2nd stage plate balance can be adjusted as outlined in the Maintenance section of this manual.

e. DIFFERENTIAL BALANCE. The differential input makes possible the application of balanced inputs

to the preamplifier. Set MILLIVOLTS/CM switch to 1 for best rejection ratio for common-mode signals. The rejection ratio will remain about 10,000 to 1 in the 10, 100, and 1,000 positions of the MILLIVOLTS/CM switch if the attenuator trimmers and balance resistors are carefully adjusted. The common-mode signal should not exceed 5 volts peak-to-peak at the grid of the first stage, to avoid distortion of the signal; therefore in the 10 and 100 positions of the MILLIVOLTS/CM switch it should not exceed 50 volts and 500 volts respectively. Use of the probes ahead of the preamplifier reduces the rejection ratio to about 50 to 1 because of the 1 percent tolerance of the probe resistors.

5. CIRCUIT DESCRIPTION.

a. GENERAL. The Model 1824 preamplifier has a minimum passband to 350 Kc and a maximum passband to 2 Mc, depending upon sensitivity. It has four calibrated sensitivity steps and six multiplier positions for each step. The attenuation is made continuously variable by the variable attenuator control filling in between steps. The VERTICAL POSITIONING control is located in the plug-in unit. This is possible because the remainder of the vertical amplifier system is DC-coupled so that a DC change at this level becomes a DC change at the CRT deflection plates.

b. INPUT CONNECTORS. Either of two input connectors can be switched into the input circuits by means of the Input Selector Switch S1101. In either the A or-B positions of the switch, one of the grids is grounded and the other is left free for signal input. Both grids are left free in the A-B position for signal inputs. C1101 and C1102 capacitors are shorted out in the DC positions.

c. ATTENUATORS. Various frequency compensated attenuators are inserted between the input connectors and signal grids of the input stage, by means of the MILLIVOLTS/CM switch. Attenuation ratios are 1, 10, 100, and 1,000. A cascode push-pull amplifier stage is made up of V1101 and V1102. The V1103B is a voltage setting cathode follower. The DIFF. BAL. control R1111 adjusts the relative DC levels of the two grounded grids of the cascode amplifier stage. This control is used to equalize the gain of the two halves of the stage for maximum rejection of common-mode signals with differential input. The PREAMP BALANCE switch S1103, provides a coarse adjustment of the DC level on the plate of V1102B and the concentric FINE adjustment varies the DC level on V1101B so the input to the next stage can be balanced.

d. OUTPUT STAGE. A push-pull gain stage is comprised of V1104 and V1105. Screen voltage for this stage is supplied by V1103A, a voltage setting cathode follower. Adjusting gain in fixed steps is accomplished by the MULTIPLIER switch S1104, which selects fixed resistors for plate loads of the cascode and output amplifiers. GAIN ADJ. R1130 and VARIABLE R1133 also adjust the gain of this stage. This is accomplished by varying the cathode coupling between the two tubes.

e. OUTPUT STAGE CONTROLS. Screen potentials of the two tubes are adjusted by R1137, marked VAR. ATTEN. BAL. This adjustment is necessary to stabilize the vertical shift of the trace when GAIN ADJ. or VARIABLE controls are varied. R1143, marked 2ND STAGE PLATE BAL., balances the output of this stage so the input to the cathode follower stage will be balanced. V1106 is a cathode follower stage to drive the main amplifier. R1150, marked VERTICAL POSITION, adjusts the relative DC potentials of the two cathodes to position the trace vertically. Adjusting the relative bias on the grids of V1106 to permit centering the trace vertically with the VERTICAL POSITION control set at midrange, is accomplished by R1146, marked VERT. POS. RANGE.

f. HEATERS. The heaters of all the tubes in this unit use DC current supplied by terminal 15 of the connecting plug to operate the heater string.

6. MAINTENANCE INSTRUCTIONS.

a. GENERAL. Ordinarly, adjustment in the field will consist of merely touching up some of the DC level and balance controls. If a complete readjustment is necessary the sequence of adjustments outlined in paragraph 7 should be followed. Specific troubleshooting points are outlined in table 1-3.

7. OPERATION ADJUSTMENTS.

a. To make the following adjustments, it is necessary to have an EP53 plug in extension to permit the preamplifier to be operated outside the oscilloscope, although most of the adjustments can be made with the side panels removed and the unit plugged in. Plug in the preamplifier either directly or by extension. Turn unit on and allow 15 minutes for warm-up-drift to cease. Free run the oscilloscope sweep at some convenient rate so that a trace is visible on the CRT face.

b. Positioning Adjustment. Place a jumper from the plate pin 8 of V1104 to the plate pin 8 of V1105. Center the vertical position control and adjust the vertical position range until the trace is centered vertically. Do not change the position of either of these controls while making the following adjustments.

c. 2ND STAGE DC BALANCE. Remove the jumper from the plates of the 2ND stage and connect it between the grid, pin 1, of V1104 and the grid, pin 1, of V1105. If the trace shifts vertically when rotating the VARIABLE attenuator back and forth, adjust VAR. ATTEN. BAL. until the trace does not shift position when attenuator is rotated. Adjust the 2nd stage PLATE BAL. if trace is no longer centered. Do not move the VERTICAL POSITION control. If a slight interaction occurs between the 2ND STAGE PLATE BALANCE and VAR. ATTEN. BAL., rotate the VARIABLE attenuator, after centering the trace with 2ND STAGE PLATE BAL., and see if the trace shifts position. Readjust the VAR. ATTEN. BAL. until the trace no longer shifts.

Rotate the MULTIPLIER switch between 1 and 5. If trace shifts slightly, readjust the 2ND STAGE PLATE BAL. until the trace no longer moves when MULTIPLIER switch is rotated. Remove jumper wire and connect

it to the grid, pin 2 of V1101A, and the grid, pin 2, of V1102A. Center the DIFF. BAL. control. Center the trace with the PREAMP BALANCE control on the front panel. Be sure to remove jumper before proceeding.

d. DIFFERENTIAL BALANCE. To obtain maximum rejection of common-mode signals, two adjustments are needed. The first adjustment will balance the input stage and the second will provide equal attenuation for each input when using MILLIVOLTS/CM switch on outside of panel. The first adjustment is the amplifier differential balance and is performed by connecting a 10 volt signal from the oscilloscope calibrator to input A and input B. Turn selector switch to A-B position and set MILLIVOLTS/CM switch to 1 and the MV/CM MULTIPLIER to 1. When this is done, adjust DIFF BAL control while trace is centered with PREAMP BALANCE control for minimum deflection. It is helpful to start with MV/CM MULTIPLIER at 10 or 20 if these controls are far out of adjustment. Try interchanging tubes V1101 and V1102 if the DIFF BAL control does not have sufficient range, as this indicates excessive difference in the characteristics of the two tubes. If balance still cannot be obtained, replace the two tubes V1101 and V1102.

To adjust the attenuator balance the second adjustment required, adjust the attenuator balance resistors for minimum vertical deflection on the CRT. The table below indicates the calibrated voltages to be applied simultaneously to input A and input B and the settings of the MILLIVOLTS/CM switch to be used during this adjustment.

Cal. Volts	Millivolts/CM Switch	Adjust
20	10	R1155
50	100	R1160
100	1000	R1168

e. GAIN ADJUSTMENT. The calibration of the MILLIVOLTS/CM switch is determined by this adjustment which also determines the gain of the plug-in-unit. Connect a 10 MV signal from the oscilloscope calibrator to input A. Turn the input selector to A, DC, set the MILLIVOLTS/CM switch to 1, and the MV/CM MULTIPLIER to 5. Turn the VARIABLE control clockwise to the calibrated position and adjust the gain adjustment control until the displaced waveform is four major graticule divisions in amplitude.

f. ATTENUATOR COMPENSATION. The following adjustments should be made with a fast rise, square-wave generator. The oscilloscope calibrator can be used, but it is easy to over-compensate the adjustments because of the slower rise of the calibrator waveform. An input capacitance standardizer is available from the factory to aid in setting the input capacitance of 47 uuF. This is of great value when probes are to be used with several plug-in units. A standard capacitance makes it unnecessary to readjust the probe for each plug-in unit.

1. Output Divider Compensation. The attenuation is the same for high frequencies, as for low frequencies, due to the capacitors C1113 and C1114 which compensate the output dividers. Connect the terminated cable from the square wave generator in input A. Turn the input switch to A, DC. Turn the MILLIVOLTS/CM switch to 1, and the MV/CM MULTIPLIER to 50. Set the square wave generator to 100 kc and display 5 to 10 square waves. Adjust C1113 and C1114 for a square corner on square wave.

2. INPUT A Capacitance Adjustments. The input capacitance is adjusted to 47 uuF by using an Input Capacitance Standardizer. Connect the 47 uuF Input Capacitance Standardizer to INPUT A. Connect the calibrator output of the scope or the output of a square-wave generator (frequency set to 1 Kc) to the Input Capacitance Standardizer and turn the input-selector switch to A, DC. Turn the MILLIVOLTS/CM switch to 1 and the MV/CM MULTIPLIER to 50. Then adjust C1103 capacitor for a flat top on the square-wave.

3. Input B Capacitance Adjustment. Move the 47 uuF standardizer from input A to input B connector, and turn the input selector switch to -B, DC. Adjust C1104 capacitor for a flat bottom on the square wave.

4. Input Capacitance Neutralization. The capacitors C1105 and C1107 compensate for grid to cathode capacitance in the input amplifier stage. Remove the standardizer and connect the square-wave generator to INPUT A. Turn the input selector switch to A-B, DC, and adjust the capacitor C1107 for a flat top on the square wave. Move the square-wave generator connection to INPUT B and adjust the capacitor C1105 for a flat bottom on the square-wave. Repeat steps 2 and 3. If considerable readjustment is necessary, repeat step 4 as there is interaction between adjustments.

5. High-Frequency Differential Balance. To provide a high-frequency differential balance adjustment, capacitor C1106 varies the plate-to-cathode capacitance of V1102A. Connect a 10 volt signal from oscilloscope's calibrator to both INPUT A and INPUT B. Turn the input-selector switch to A-B, DC. Set MILLIVOLTS/CM switch to 1 and MV/CM MULTIPLIER to 1. If necessary readjust the DIFF. BAL. control as described in paragraph "d." Adjust C1106 for minimum amplitude of spikes on the waveform.

6. Input A Attenuator Compensation. In order to achieve proper compensation, two types of adjustments are necessary. One type of adjustment makes the AC attenuation equal to the DC attenuation of the voltage dividers, the other type of adjustment makes the input capacitance 47 uuF in all settings of the attenuator switches. To accomplish the adjustment, connect the output of the calibrator to INPUT A. Turn the input selector switch to A, DC, and adjust each capacitor indicated in the following table for a flat top, and a square corner on the top of the square-wave with the MILLIVOLTS/CM switch in the position indicated.

MILLIVOLTS/CM	CAPACITOR
10	C1118
100	C1122
1000	C1128

Now connect the 47 uuF Input Capacitance Standardizer to INPUT A and connect the output of the calibrator to the standardizer. Adjust the input capacitance with the MILLIVOLTS/CM switch in the positions shown for a flat top, and a square corner on the top of the square-wave.

MILLIVOLTS/CM	CAPACITOR
10	C1116
100	C1120
1000	C1126

7. Input B Attenuator Compensation. Connect the output of the calibrator to INPUT B. Turn the input selector switch to -B, DC, and adjust each capacitor indicated in the following table for a flat bottom and a square corner on the bottom of the square wave with the MILLIVOLTS/CM switch in the position indicated.

MILLIVOLTS/CM	CAPACITOR
10	C1119
100	C1125
1000	C1131

Now connect the 47 uuF Input Capacitance Standardizer to INPUT B and connect the output of the calibrator to the standardizer. Adjust the input capacitance with the MILLIVOLTS/CM switch in the positions shown for a flat bottom, and a square corner on the bottom of the square wave.

MILLIVOLTS/CM	CAPACITOR
10	C1117
100	C1121
1000	C1127

TROUBLE	PROBABLE CAUSE	REMEDY
Trace cannot be centered vertically.	Preamplifier not firmly plugged in.	Fully insert preamplifier in compartment and secure with retaining knob.
	Insufficient warm-up time.	Allow at least five minutes warm-up time.
	Vertical position range control not adjusted properly.	Adjust vertical position range control (par. 7b).
Trace cannot be centered vertically.	Defective output cathode follower.	Replace V1106
Trace shifts when multiplier is rotated.	Preamp balance adjustment.	Adjust preamp balance (par. 4d).
	Defective cascode amplifier.	Replace V1101 and/or V1102.
Trace shifts when "GAIN ADJ" or "VARIABLE" controls are adjusted.	Variable attenuator balance out of adjustment.	Adjust R1137 (var. atten. bal.) (par. 5e).
	Defective output amplifier.	Replace V1104 and/or V1105.

Table 1-3. Trouble Shooting

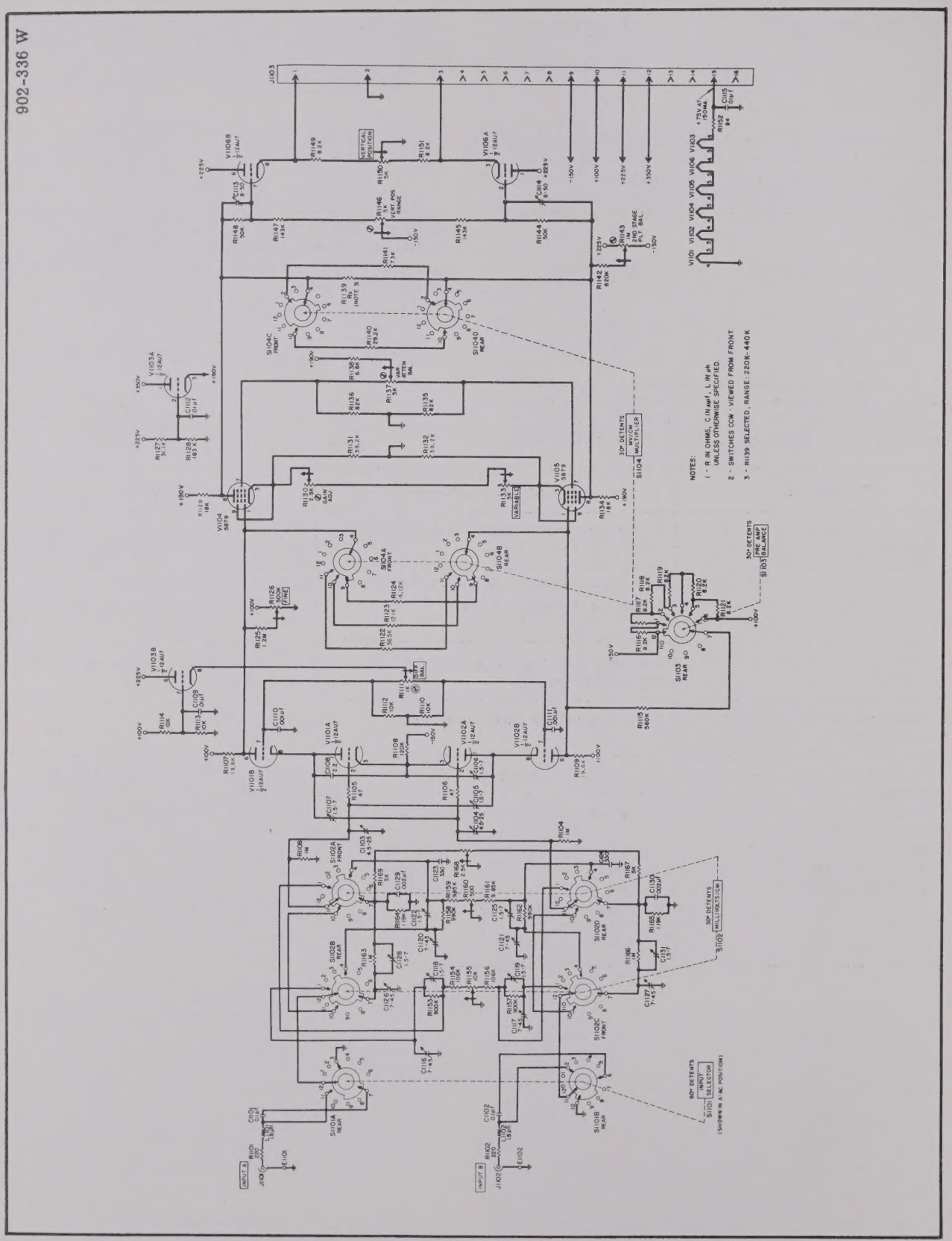

Figure 1-3. Schematic Diagram for Model 1824 Preamplifier

SECTION II

PARTS BREAKDOWN

1. GENERAL. All parts of the Model 1824 preamplifier are listed in alpha-numerical order according to reference symbols. Each part is illustrated one or more times on figures 2-1, 2-2, and 2-3. The parts are called out on the illustrations by reference designator which correspond with the replacement parts list and the schematic.

2. USE OF REPLACEMENT PARTS LIST.

a. Finding the part number and description. Identify part on applicable illustration in Section II, when reference symbol or part number is known and a replacement part is required.

b. Locate reference symbol assigned to part in illustration in "Ref. Symbol" column of replacement parts list. Part number is listed opposite reference symbol in Part Number column. "Description" column contains identifying characteristics nomenclature.

c. Finding applicable illustration and description. When reference symbol is known but physical location is unknown, find reference symbol in replacement parts list. Figure number on which part is shown is listed in "Located on Figure No." column.

3. REPLACEMENT PARTS. All replacement parts may be purchased from Hickok Electrical Instrument Company, 10514 Dupont Avenue, Cleveland 8, Ohio.

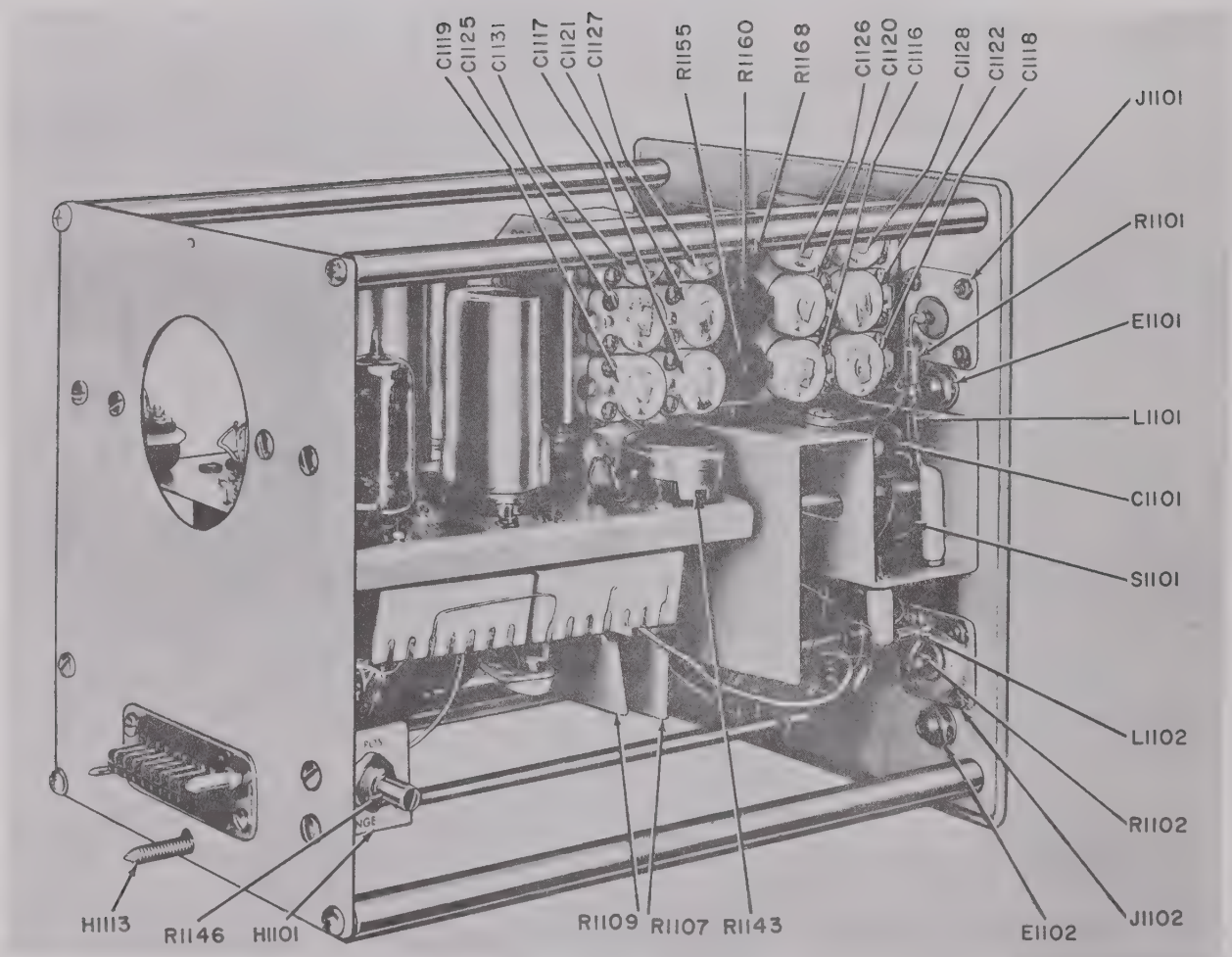

Figure 2-1. Location of Parts on Left Side

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
C1101	3105-268	CAPACITOR, FIXED: paired to 1% (0.1. ufd normal)	1 pr.	2-1
C1102		Same as C1101		2-2
C1103	3115-20	CAPACITOR, VARIABLE: CERAMIC, 4.5 uuf, 20%, 500V	2	2-3
C1104		Same as C1103		2-3
C1105	3115-16	CAPACITOR, VARIABLE: CERAMIC, 1.5-7 uuf, 20% 500V	9	2-2
C1106		Same as C1105		2-2
C1107		Same as C1105		2-2
C1108	3110-103	CAPACITOR, FIXED: CERAMIC, 2.2 uuf, $\pm$0.5 uuf, 500V	1	2-2
C1109	3110-64	CAPACITOR, FIXED: CERAMIC, 0.01 uf, 500V, +100 -20%, disc type	3	2-2
C1110	3110-107	CAPACITOR, FIXED: CERAMIC, 0.001 uf, GMV disc, 500V	2	2-2
C1111		Same as C1110		2-2
C1112		Same as C1109		2-2
C1113	3115-22	CAPACITOR, VARIABLE: 8-50 uuf	2	2-2
C1114		Same as C1113		2-2
C1115		Same as C1109		2-2
C1116	3115-21	CAPACITOR, VARIABLE: CERAMIC, 7-45 uuf, 20%, 500V	6	2-1
C1117		Same as C1116		2-1
C1118		Same as C1105		2-1
C1119		Same as C1105		2-1
C1120		Same as C1116		2-1
C1121		Same as C1116		2-1
C1122		Same as C1105		2-1
C1123	3095-55	CAPACITOR, FIXED: MICA, 330 uuf, 10% 500V (Spec. MIL-C-5/2A)	3	2-3
C1124		Same as C1123		2-3
C1125		Same as C1105		2-1
C1126		Same as C1116		2-1
C1127		Same as C1116		2-1
C1128		Same as C1105		2-1

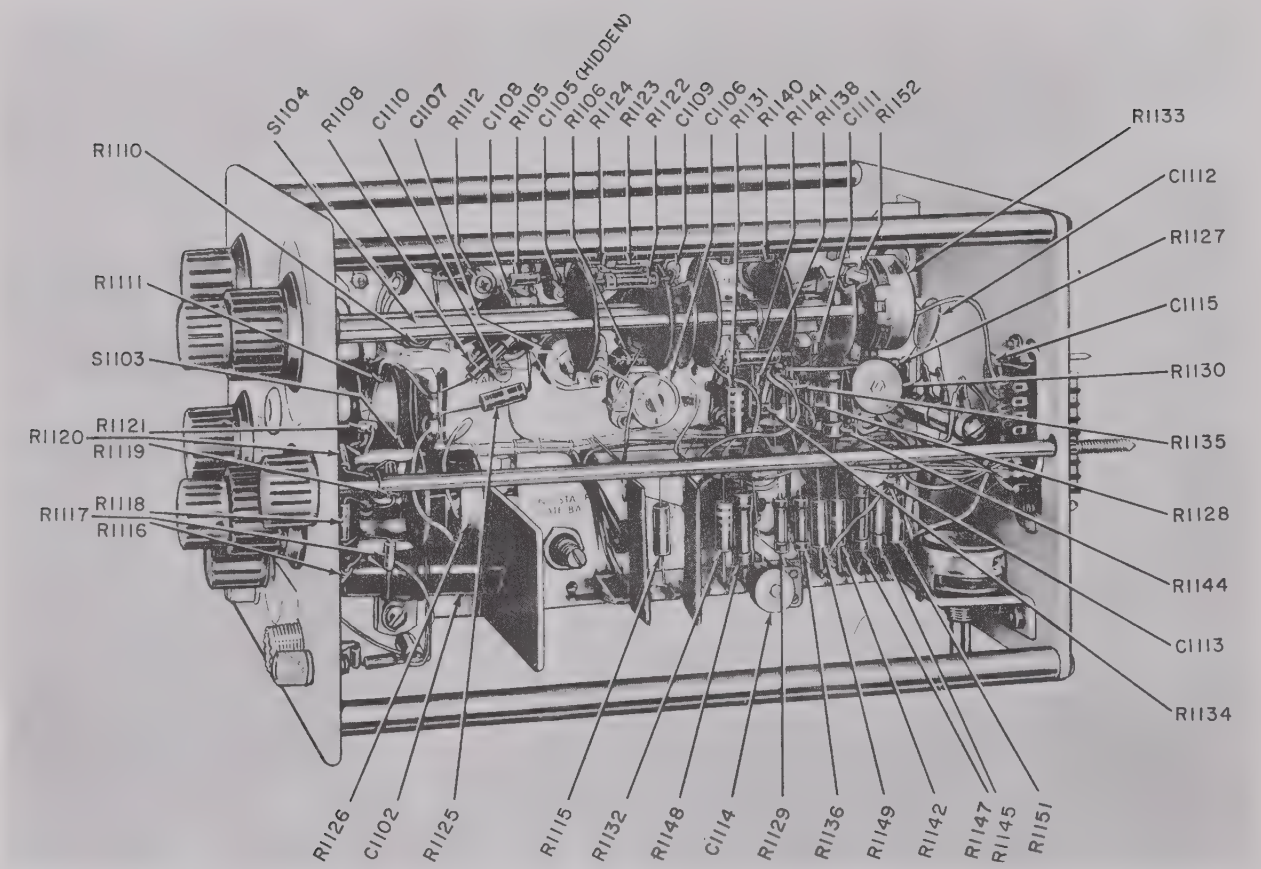

Figure 2-2. Location of Parts on Right Side

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
C1129	3095-118	CAPACITOR, FIXED: MICA 2000 uuf, 5%, 500V	2	2-3
C1130		Same as C1129		2-3
C1131		Same as C1105		2-1
E1101	2360-86	Binding post	2	2-1
E1102		Same as E1101		2-1
E1103	19155-140	SHIELD, TUBE, 9 pin socket, 1-15/16" lg., brass, nk. pl.	4	2-3
H1101	B/W2660-790	BRACKET, VERT. POS., iridite dip, silk screened	1	2-1
H1113	19100-113	SHAFT: LOCKING, plug-in-unit, 0.188 dia, 10-24 thread x 10 5/16 in. lg., steel nk. pl.	1	
J1101	3475-92	CONNECTOR, Mica filled phenolic, with polystyrene base disc	2	2-1
J1102		Same as J1101		2-1
L1101	3320-170	COIL: FIXED, 1.8 uh	2	2-1
L1102		Same as L1101		2-1
R1101	18411-221	RESISTOR, FIXED, COMPOSITION, 220 ohms, 5% 1/2 watt	2	2-1
R1102		Same as R1101		2-1
R1103	18350-95	RESISTOR, FIXED, film, 1 megohm, 1%, 1/2 watt	4	2-3
R1104		Same as R1103		2-3
R1105	18410-472	RESISTOR, FIXED, COMPOSITION, 47 ohms, 10% 1/2 watt	2	2-2
R1106		Same as R1105		2-2
R1107	18551-154	RESISTOR, FIXED, FILM, 19.6K ohms, 1%, 1/2 watt	2	2-1
R1108	18530-19	RESISTOR, FIXED, film, 120K ohms, 1%, 1/2 watt	1	2-2
R1109		Same as R1107		2-1
R1110	18575-246	RESISTOR, FIXED, WIRE WOUND, 10,000 ohms, 5%, 5 watt (No brackets)	4	2-2
R1111	40101-102	RESISTOR, VARIABLE, COMPOSITION 1000 ohms 20%, 2 watt, linear taper, 3/8" bushing length, 7/8" shaft length from mtg surface, screw driver slot	1	2-2
R1112		Same as R1110		2-2
R1113		Same as R1110		
R1114		Same as R1110		
R1115	18424-562	RESISTOR, FIXED, COMPOSITION, 560K ohms, 10% 1 watt	1	2-2

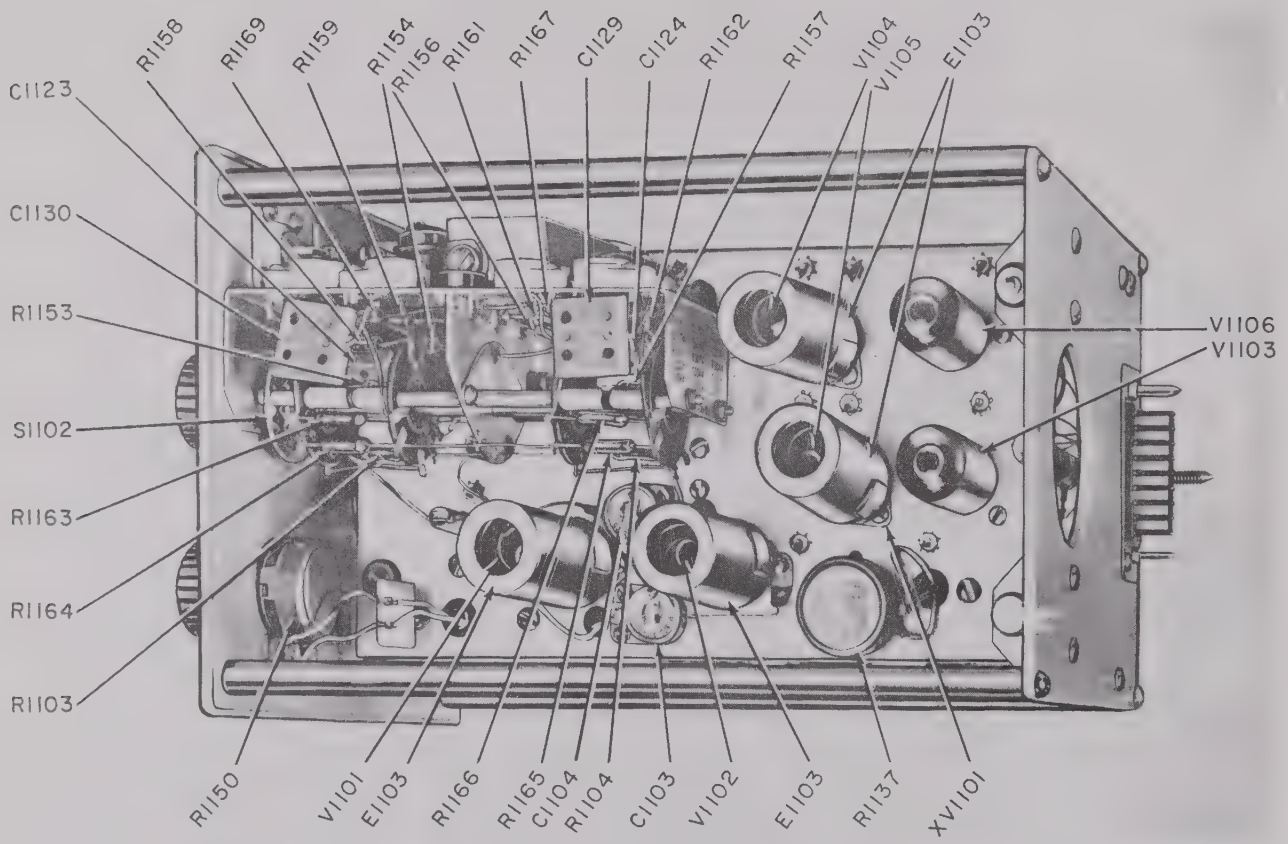

Figure 2-3. Location of Parts from Top View

SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R1116	18412-822	RESISTOR, FIXED, COMPOSITION, 8200 ohms, 10%, 1/2 Watt	6	2-2
R1117		Same as R1116		2-2
R1118		Same as R1116		2-2
R1119		Same as R1116		2-2
R1120		Same as R1116		2-2
R1121		Same as R1116		2-2
R1122	18694-443	RESISTOR, FIXED, FILM, 36.5K ohms, 1%, 1/2 watt	1	2-2
R1123	18694-397	RESISTOR, FIXED, FILM, 12.1K ohms, 1/2 watt, 1%	1	2-2
R1124	18694-352	RESISTOR, FIXED, FILM, 4120 ohms, 1%, 1/2 watt	1	2-2
R1125	18425-112	RESISTOR, FIXED, COMPOSITION, 1.2 megohms, 10%, 1 watt	1	2-2
R1126	40101-504	RESISTOR, VARIABLE, COMPOSITION, 500K ohms, 20%, 2 watt, linear taper, 3/8" bushing length, 7/8" shaft length from mtg surface, screw driver slot	1	2-2
R1127	18530-131	RESISTOR, FIXED, FILM 31.1K ohms, 1%, 1/2 watt	1	2-2
R1128	18530-127	RESISTOR, FIXED, FILM 183K ohms, 1%, 1/2 watt	1	2-2
R1129	18530-123	RESISTOR, FIXED, FILM, 18K ohms, 1%, 1/2 watt	2	2-2
R1130	16925-350	RESISTOR, VARIABLE, COMPOSITION 2.5K ohms, 20%, 1/10 watt, 5/8" dia.	2	2-2
R1131	18531-37	RESISTOR, FIXED, FILM, 39.2K ohms, 1%, 1 watt	2	2-2
R1132		Same as R1131		2-2
R1133	40101-502	RESISTOR, VARIABLE, COMPOSITION 5000 ohms, 20%, 2 watt, linear taper, 3/8" bushing length, 7/8" shaft length from mtg surface, screw driver slot	4	2-2
R1134		Same as R1129		2-2
R1135	18530-132	RESISTOR, FIXED, FILM 82,000 ohms, 1%, 1/2 watt	2	2-2
R1136		Same as R1135		2-2
R1137		Same as R1133		2-3
R1138	18412-682	RESISTOR, FIXED, COMPOSITION, 6800 ohms, 10% 1/2 watt	1	2-2

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R1139		Not Assigned		
R1140	18530-125	RESISTOR, FIXED, FILM, 29, 200 ohms, 1%, 1/2 watt	1	2-2
R1141	18530-124	RESISTOR, FIXED, FILM, 7300 ohms, 1%, 1/2 watt	1	2-2
R1142	18424-822	RESISTOR, FIXED, COMPOSITION, 820K ohms, 10%, 1 watt	1	2-2
R1143	40101-105	RESISTOR, VARIABLE, COMPOSITION, 1 megohm, 20%, 2 watt, linear taper, 3/8" bushing length, 7/8" shaft length from mtg surface, screw driver slot	1	2-1
R1144	18531-2	RESISTOR, FIXED, FILM, 50K ohms, 1%, 1 watt	2	2-2
R1145	18531-13	RESISTOR, FIXED, FILM, 143K ohms, 1%, 1 watt	2	2-2
R1146		Same as R1133		2-1
R1147		Same as R1145		2-2
R1148		Same as R1144		2-2
R1149	18422-822	RESISTOR, FIXED: COMPOSITION 8. 2K ohms, 10%, 1 watt	2	2-2
R1150		Same as R1133		2-3
R1151		Same as R1149		2-2
R1152	18575-241	RESISTOR, FIXED, WIRE WOUND, 84 ohms, 5%, 5 watt	1	2-2
R1153	18530-69	RESISTOR, FIXED, FILM, 900K ohms, 1%, 1/2 watt	2	2-3
R1154	18530-69	RESISTOR, FIXED, FILM, 106K ohms, 1%, 1/2 watt	2	2-3
R1155	16925-360	RESISTOR, VARIABLE, COMPOSITION, 10, 000 ohms, 20%, 1/10 watt, 5/8" dia.	1	2-1
R1156		Same as R1154		2-3
R1157		Same as R1153		2-3
R1158	18530-96	RESISTOR, FIXED, FILM, 990K ohms, 1%, 1/2 watt	2	2-3
R1159	18530-130	RESISTOR, FIXED, FILM, 9.85 K ohms, 1%, 1/2 watt	2	2-3
R1160	16925-349	RESISTOR, VARIABLE, COMPOSITION, 500 ohms, 20%, 1/10 watt, 5/8"	1	2-1
R1161		Same as R1159		2-3
R1162		Same as R1158		2-3

REF. SYMBOL	PART NUMBER	DESCRIPTION	QUANT. PER EQUIP.	LOCATED ON FIGURE NO.
R1163		Same as R1103		2-3
R1164	18530-133	RESISTOR, FIXED, FILM, 1.19K ohms, 1% 1/2 watt (MIL-R-10509C)	2	2-3
R1165		Same as R1164		2-3
R1166		Same as R1103		2-3
R1167	18530-55	RESISTOR, FIXED, FILM, 5000 ohms, 1%, 1/2 watt (MIL-R-10509C)	2	2-3
R1168		Same as R1130		2-1
R1169		Same as R1167		2-3
S1101	19912-408	SWITCH, ROTARY, 2 phenolic wafers, 6 position (MIL-S-3786) (Input selector)	1	2-1
S1102	19912-410	SWITCH, ROTARY, 4 phenolic wafers, 4 position (MIL-S-3786) (Millivolts/CM)	1	2-3
S1103	19912-409	SWITCH, ROTARY, 1 phenolic wafer, 7 position, (MIL-S-3786)	1	2-2
S1104	19912-407	SWITCH, ROTARY, 4 phenolic wafers, 6 position (MIL-S-3786) (MULTIPLIER)	1	2-2
V1101	20877-16	TUBE, ELECTRON 12AU7 (paired)	2	2-3
V1102		Same as V1101		2-3
V1103	20875-69	TUBE, ELECTRON 12AU7	2	2-3
V1104	20877-17	TUBE, ELECTRON 5879 (paired)	2	2-3
V1105		Same as V1104		2-3
V1106		Same as V1103		2-3
XV1101		SOCKET, MICA filled, phenolic 4 gr. lugs	6	2-3